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Smart Coffee Machine

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Disclaimer

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Abstract

We are undertaking a project to develop a smart coffee machine using coffee capsules designed to provide coffee enthusiasts with a seamless coffee experience, regardless of their familiarity with the intricacies of coffee preparation. This innovative machine empowers users to effortlessly customize their coffee choices, including the coffee type, desired quantity, and additional preferences.

This project encompasses pivotal components, including mobile application and remote ordering capabilities, as well as card payment functionality. It integrates specialized input units within the device. Furthermore, it automates the coffee-making process, eliminating the need for extensive user involvement. Additionally, it meticulously regulates water temperature to guarantee the consistent delivery of high-quality coffee. Ultimately, this project aspires to provide coffee enthusiasts with a seamless and user-friendly coffee experience.

In brief, the device operates as follows: Initially, it features an input unit that prompts users to input information regarding their coffee preferences. This includes selecting from various coffee capsules with different flavors, specifying the desired quantity, and indicating any additional preferences. Subsequently, the device automatically manages the coffee preparation process. It begins by selecting the appropriate coffee capsule and placing it in the designated slot. The device then heats the water to a precise temperature and manages the flow of hot water through the capsules to extract the coffee drink. Once the coffee preparation is complete, it is dispensed through an output unit for serving.

What sets our project apart from numerous coffee-making machines on the market is its emphasis on user-friendliness, convenience, and automation. Furthermore, it leverages coffee capsules, reducing the need for users to grind coffee beans and ensuring consistently high-quality coffee due to the preservation method of the capsules. Additionally, our system offers a different flavor through a diverse range of coffee capsules.

1 Introduction

1.1 General background

The smart coffee machine is an advanced version of coffee makers that use flavored capsules to prepare coffee. It automates the entire preparation process, eliminating the need for the person brewing coffee to have expertise in the brewing process. This machine offers a wide range of flavors and options, aiming to provide users with ease and convenience.

1.2 Objectives

The aim of the Smart Coffee Machine is to automate the process of making coffee using capsules. This machine enables users to order their preferred flavor, and the preparation process will be completed automatically. Moreover, users can place their orders through a mobile application. The machine is equipped with sensors that determine whether the required ingredient proportions for preparation are adequate or not. These functionalities make the machine we have developed stand out from other machines.

1.3 Scope of work

During the project, we followed a comprehensive strategy that involved multiple stages. Firstly, we identified the most appropriate features for our machine and carefully selected suitable components such as sensors, motors, heaters, drivers, and printed parts. Additionally, we determined the required controller for the system to ensure seamless operation. To simplify the process, we divided the project into separate units, including Input/Output, Heating, Drink Preparation, and Dispensing units. Each unit underwent a rigorous testing process in isolation before being integrated into the overall design of the machine. Following this, dependent units were tested to ensure flawless functionality. Finally, we created an algorithm to efficiently control the machine and conducted extensive tests on the integrated system to ensure optimal performance in all possible scenarios.

1.4 Significance

The ability to prepare coffee using capsules in an automatic way is causing a revolution in the world of coffee machines that operate with capsules. In addition to integrating technology into the development process, this machine enables us to place orders using an application. Here lies the fundamental idea of the smart coffee machine, allowing the user to choose their preferred type of coffee, add some ingredients, and have the entire brewing process occur automatically.

1.5 Organization of the report

This report is organized into several sections. The introduction provides an overview of the project and its objectives. The second section describes the scope and boundaries of the work. The third section outlines the methodology and procedures followed in completing the project. The fourth section presents the results and findings, including any challenges encountered and how they were overcome. The fifth section discusses the significance and potential impact of the project. Finally, the conclusion summarizes the key points of the report and provides recommendations for future work. Appendices are also included to provide additional information and data relevant to the project.

2 Constraints and Earlier Coursework

2.1 Constraints & Limitations

Through designing and building our machine, we faced multiple constraints:

- DC motor - We had difficulty finding a DC motor that could compress the capsule with the force we wanted, so we resorted to taking a DC motor from a car window, which is an 8A DC motor.

- We faced an issue with the temperature of the liquid components, so we used plastic pipes capable of withstanding certain temperature levels. Therefore, the challenge was determining the appropriate temperature.

- pumps -We faced some issues controlling the flow of milk and coffee from both heaters toward the cup when using the valves. Therefore, we replaced the valves with pumps to control the flow of coffee and milk in a smooth and efficient manner.

- Designing the shape of the machine - We faced some challenges in determining the appropriate design for certain components of the machine, in addition to placing them in the right location to ensure the smooth flow of the beverage into the cup. We needed to use wooden bases to elevate the heaters and the espresso machine to achieve this.

2.2 Standards and Codes

The system's software components comprise of an Arduino C++ program that incorporates several libraries and functions such as Keypad.h, LiquidCrystalI2C.h, wire.h, OneWire.h and DallasTemperature.h. The user interface was developed using web developing languages, while the backend and database were constructed using Firebase. The design and implementation of the software components adhere to the relevant industry standards and codes.

2.3 Earlier Courses

2.3.1 Networks course

provided us with a deep understanding of communication protocols and essential networking principles. Thanks to this knowledge, we were able to design a networking infrastructure for our machine. This task proved to be crucial since our goal was to develop a system that allows users to operate the machine remotely through a dedicated app.

2.3.2 Electronic Circuits

provided a solid foundation in the fundamental principles of electronics, which proved to be extremely useful in designing and troubleshooting hardware components for the machine. This knowledge was particularly valuable when working with sensors, motors, valves, and pumps. Finally, the course was instrumental in developing the necessary skills for working with electronic components and their applications.

2.3.3 Microcontroller

particularly focusing on the PIC controller, proved immensely beneficial. It deepened our understanding of microcontroller programming, a pivotal element in constructing our machine using the Arduino Mega. Additionally, we developed the expertise to interface with diverse components and employ various techniques. The insights gained from this course empowered us to adeptly write the code encompassing the essential algorithm for our machine, serving as the project's core.

2.3.4 Critical Thinking course

The project greatly benefited from the Critical Thinking course, as it played a pivotal role in guiding us to systematically approach the tasks and make well- informed decisions. Equipped with critical thinking skills, we were able to pinpoint potential challenges, thoroughly analyze them, and suggest practical solutions. This proved particularly valuable when encountering design and power-related issues throughout the project.

3 Literature Review

This section will review related literature on coffee vending machines, including concepts, smart coffee vending machines that use sensor and actuator networks, and innovative coffee machine design projects.

" Smart Coffee Vending Machine Using RFID"
Rahul Jadhv, Mrunali Jejurkar, and Pranita Kave developed a smart coffee vending machine that uses RFID technology to control product consumption and reduce waste in low-budget scenarios. The project also stores historical data in EPROM. While the study is not directly related to the Caffeine Shot Machine, it demonstrates the benefits of using technology to reduce waste and improve product monitoring.[1]

" Smart Coffee Vending Machine Using Sensor and Actuator Networks"
Kwangsoo Kim, Dong-Hwan Park, Hyochan Bang, and Geonsoo Hong introduced a smart vending machine that automatically measures its own indoor environmental conditions and controls the amount of coffee, sugar, and powdered coffee creamer to make a cup of coffee according to the customer's preference on taste. The study shows the potential for sensor and actuator networks to improve the customizability of coffee vending machines, which is a goal of the Caffeine Shot Machine.[2]

"Coffee Machine Design Project Through Innovative Methods, QFD, Value Analysis, and Design for Assembly"
This research showcases the potential of innovative methodologies in enhancing the design process for uncomplicated items such as a coffee machine. Quality Function Deployment, Value Analysis, and Design for Assembly are three approaches employed to enhance the quality of the design process. The study highlights how a well-structured design process can result in a product that is easier to assemble and of superior quality, aligning with the fundamental objective of the Caffeine Shot Machine.

"Smart Espresso Machine"
The literature review explores the interaction capabilities of a Smart Espresso Machine (SEM) developed by Austaller, Aitenbichler, and Kangasharju from Darmstadt University of Technology, Germany. The SEM integrates a microcontroller, RFID-reader, and Bluetooth module into a standard espresso machine, enabling control via computer or cellphone. Notably, the machine automatically detects inserted cups using the RFID-reader and associates them with users via personalized RFID-tags,

acceptance in pervasive computing, highlighting the need for natural interactions and feedback mechanisms. Their findings, based on extensive user testing and experience, underscore the significance of intuitive interfaces and contextual feedback in enhancing user satisfaction with smart appliances like the SEM. This study contributes valuable insights into optimizing user experience and acceptance in pervasive computing applications.
imitating a tailored coffee-making experience. The authors emphasize the importance of user acceptance in pervasive computing, highlighting the need for natural interactions and feedback mechanisms. Their findings, based on extensive user testing and experience, underscore the significance of intuitive interfaces and contextual feedback in enhancing user satisfaction with smart appliances like the SEM. This study contributes valuable insights into optimizing user experience and acceptance in pervasive computing applications.

4 Methodology

This chapter will provide an overview of the hardware components used in building the system, their connections, and the system's design. Additionally, we will delve into the system's operation and functioning process, including the software implementation, mobile application, and database utilized.

4.1 Hardware Components

4.1.1 Arduino Mega 2560

The Arduino Mega 2560 is a powerful and versatile microcontroller board that has become a staple in the world of electronics and prototyping. It is an enhanced version of the original Arduino Mega, developed by Arduino, featuring an ATmega2560 microcontroller with a substantial amount of flash memory, RAM, and a generous number of digital and analog pins. The board is particularly useful for projects that require a higher degree of complexity and connectivity. It offers 54 digital I/O pins, 16 analog inputs, and multiple communication ports. Its compatibility with a wide range of sensors, actuators, and shields makes it an ideal choice for both beginners and experienced enthusiasts. The Arduino Mega 2560 has played a significant role in countless projects, ranging from simple LED displays to sophisticated robotic systems and home automation setups, showcasing its adaptability and reliability in the realm of embedded electronics.[3]

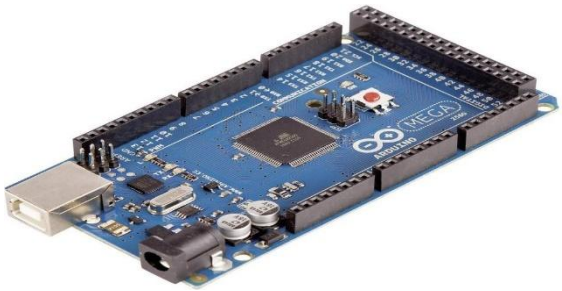

Figure 1: Arduino Mega 2560

4.1.2 J-5718HB2401 Stepper motor and A4988 driver

Stepper motors are equipped with input pins or contacts that enable the flow of current from a power source into the coil windings of the motor. By generating pulsed waveforms in the appropriate sequence, the required electromagnetic fields can be generated to drive the motor.[4]

The J-5718HB2401 stepper motor is a widely used motor that has found its application in multiple fields, such as 3D printing, CNC machines, and robotics. Despite being small and lightweight, it has enough power to perform various tasks efficiently. Additionally, it operates quietly, making it an ideal option for noise-sensitive applications.

The J-5718HB2401 stepper motor is usually used with stepper motor drivers such as DM542 or A4988 to ensure accurate control and operation. You can easily find datasheets and wiring diagrams online to make integration into your project simpler. Various manufacturers and distributors offer this motor with different lead lengths and shaft diameters to match your specific requirements.

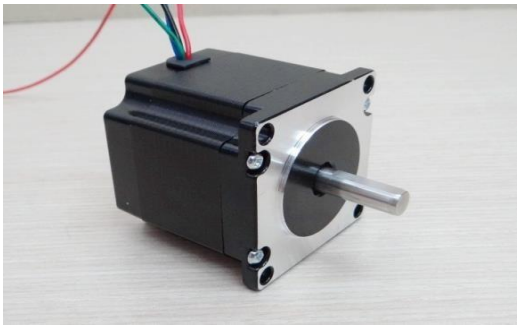

Figure 2: J-5718HB2401 Stepper motor

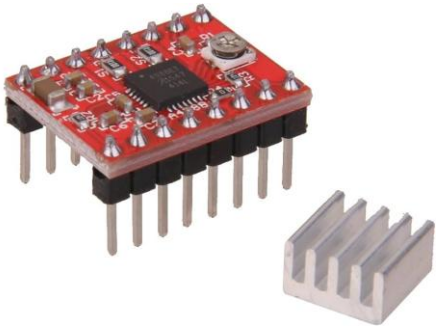

Figure 3: A988 Stepper motor driver

4.1.3 DC motor and H-Bridge

A DC motor is an electrical machine that converts electrical energy into mechanical energy. It consists of a rotating armature and a stationary field magnet, which generates a magnetic field. When an electric current is applied to the armature, a torque is generated that causes the motor to rotate. [5]

We utilized a car window DC motor for capsule compression to extract coffee from the capsules using the machine. The motor will be controlled through the H-Bridge since the compression process requires high voltage.

To control a DC motor using an Arduino, we need a hardware driver called an H-Bridge. The PWM signal produced by the Arduino has voltage and current levels that are too low to control the motor. The H-Bridge amplifies the voltage and current levels of the PWM signal, allowing for speed control. Additionally, it receives the control signal from the Arduino and switches the pole of the power supply to enable directional control. In summary, the H-Bridge serves two functions in our design: amplifying the voltage and current levels of the PWM signal for speed control and enabling directional control by switching the power supply's pole based on the control signal received from the Arduino.

Figure 4: DC motor – car window

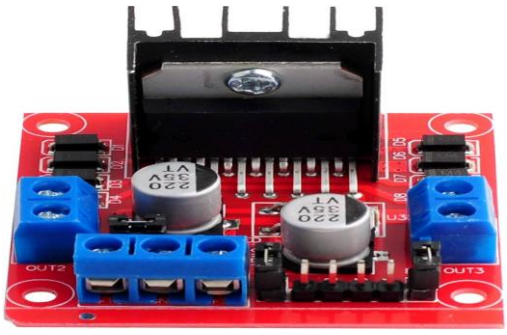

Figure 5: H-Bridge

4.1.4 Ultrasonic Sensor

An ultrasonic sensor is a device that uses sound waves with frequencies above the upper audible limit of human hearing to measure the distance to an object. The sensor emits ultrasonic waves that bounce off the object and return to the sensor. By measuring the time taken for the waves to return, the sensor can calculate the distance to the object. [6]

We used two Ultrasonic sensors to measure the levels of milk and coffee in the heaters. These sensors were used so that the person in charge of the coffee machine can monitor the levels of coffee and milk in the heaters.

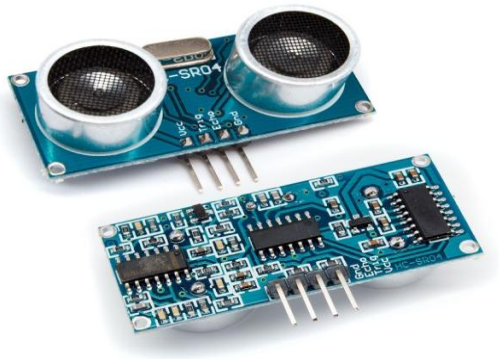

Figure 6: Ultrasonic Sensor

4.1.5 Water Temperature Sensor

We used a gyro sensor in our project to obtain the Cartesian coordinates of the submarine inside the water, which enabled us to watch the movements and directions of the submarine under the water.

Figure 7: Water Temperature Sensor

4.1.6 Limit switch sensor

Limit switch sensors are simple, electromechanical devices that detect the presence or absence of an object at a specific position. They act as physical "stop signs" or triggers for machinery and equipment, ensuring safety and proper operation.

We utilized three limit switch sensors to easily control the movement of certain components and facilitate their return to their initial positions. [8]

Figure 8: Limit switch sensor

4.1.7 Hall effect sensor

A Hall Effect sensor is a transducer that detects the presence of a magnetic field. It works based on the Hall Effect, which is the production of a voltage difference across an electrical conductor when a magnetic field is applied perpendicular to the direction of the current. In the context of sensors, Hall Effect devices are often used to measure the strength of a magnetic field or to detect the presence of a magnet.[9]

We utilized two hall effect sensors to easily control the movement of certain components and facilitate their return to their initial positions.

Figure 9: Hall effect sensor

4.1.8 Power Supply

To fulfill the voltage specifications of our project, we opted to employ a power supply. This power supply can deliver the essential 5 volts for various devices, as well as 12 volts for pumps and stepper motors. Moreover, the power supply boasts an ample current output that adequately satisfies the requirements of our project.[10]

Figure 10: Power Supply

4.1.9 Arduino Power bank

An Arduino Power Bank is a portable power supply or battery pack designed to provide energy to an Arduino microcontroller or other electronic devices. It is especially helpful in scenarios where a reliable power source is not readily available, and the Arduino needs to operate independently or in a mobile setting. These power banks are compatible with Arduino and feature USB outputs, allowing them to power not only Arduino boards but also other USB-powered devices. The capacity, size, and additional features of these power banks may vary, providing flexibility for different project requirements. They can be a convenient solution for projects requiring mobility or operation in locations without access to a continuous power source.[11]

Figure 11:Arduino Power bank

4.1.10 LCD and I2C

In our project, we employed the LCD 20x4 as a means of displaying pertinent information and instructions to the customer. This method offers a user-friendly interface, enabling the customer to easily interact with the system. The LCD screen presents prompts and inquiries, guiding the customer to input information via the keypad. Subsequently, the system processes the input and delivers suitable responses on the LCD display.[12]

Additionally, we employed the I2C Serial Interface Adapter in our setup. This compact module serves to establish a connection between a microcontroller and an LCD display by utilizing the I2C communication protocol. Acting as a mediator, it converts the parallel signals.

emitted by the display into serial signals, enabling their transmission over the I2C bus.

*Figure 12: 20*4 LCD and I2C*

4.1.11 RFID

In our project, we utilized RFID as a means of authorization. By enabling customers to scan their RFID cards, they can place orders for drinks in the regular mode. The system associates the ordered drink with their unique ID, allowing for seamless payment processing.[13]

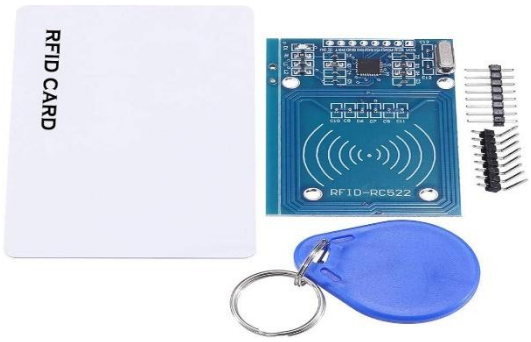

Figure 13: RFID

4.1.12 Keypad

In our project, we have used a keypad as an input device to allow customers to choose their desired beverage. This is done by displaying clear and simple instructions on an LCD screen, which accompanies the keypad. Customers can then enter their selection using the keypad to confirm their order.[14]

Figure 14: Keypad

4.1.13 Capsule base

We designed a capsule holder base where five flavors of capsules are distributed across five positions on the base. Through a stepper motor, we rotate this base to select the desired flavor. The base includes a mechanism to push the selected capsule into the espresso machine, achieved using another stepper motor. Additionally, we implemented sensors to return the base to its original position after each preparation cycle. This entire structure was 3D printed using a 3D printer.

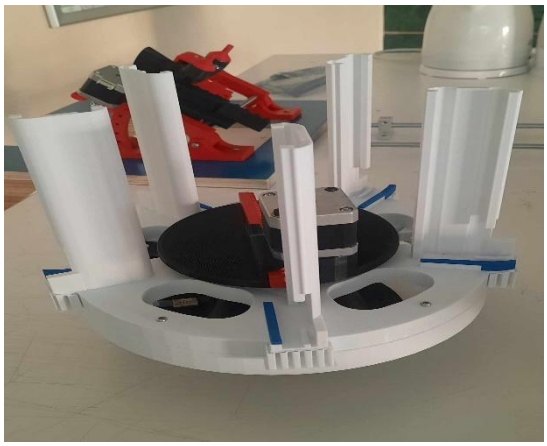

Figure 15: Capsule base

4.1.14 Espresso coffee machine

We used an old coffee machine to prepare coffee using capsules, and we upgraded it to make the process of adding and compressing the capsules automatic. Additionally, we implemented control to turn the machine on or off using a relay.[15]

Figure 16: Espresso coffee machine

4.1.15 Fixed cup holder

We have designed a fixed base to accommodate two cup sizes. We have two dedicated slots for the cups, one for the large size and the other for the small size. This base is equipped with two stepper motors and sensors to control the selection of cups and lower them onto the moving base as needed.

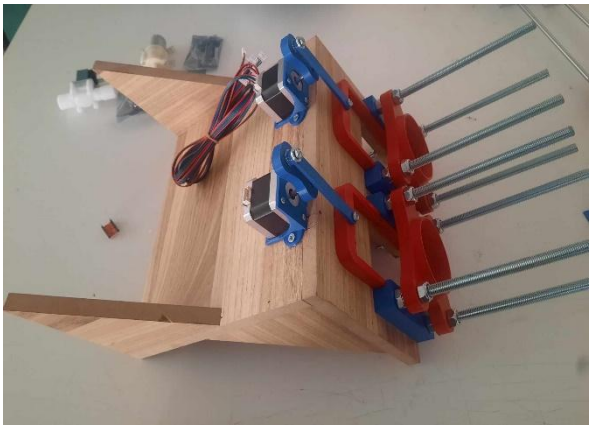

Figure 17: Fixed cup holder

4.1.16 Movable cup holder

We designed a base to hold the selected cup, which is a movable base. We used a stepper motor to control its movement, and the base is also equipped with sensors.

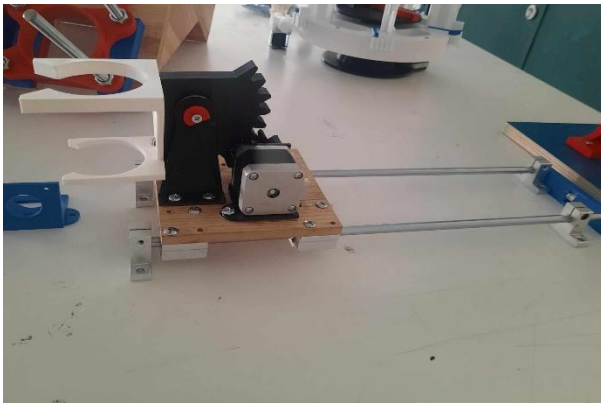

Figure 18: Movable cup holder

4.1.17 Funnel

We designed a funnel through which coffee is poured into the cup. This funnel is equipped with stirrers, allowing it to move horizontally, vertically, and at an angle. However, these movements were not utilized in the project due to our inability to provide the appropriate type of milk for the drawing process. The purpose of designing it in this way was to create art on the coffee using milk, so the funnel's task is limited to smoothly filling the cup as requested.

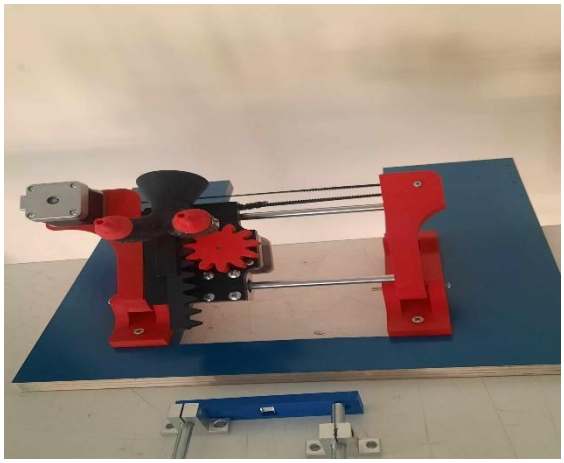

Figure 19: Funnel

4.1.18 Relay module 6 channels

A 6-channel relay module typically refers to a device that combines six distinct relay switches onto one circuit board. Each relay, or channel, can be operated independently. A relay is an electromechanical switch that reacts to an electrical signal, allowing it to either open or close.

contacts to control the flow of electrical current. In the context of a 6-channel relay module, it indicates the existence of six such switches that can be individually enabled or disabled.[16]

Figure 20: Relay module 6 channels

4.1.19 Pumps and Tubes

We incorporated two 12-volt pumps in our machine. The first pump is responsible for transferring hot coffee from the coffee heater to the cup, while the second pump transfers hot milk from the milk heater to the cup through the tubes.[17]

Figure 21: Pumps and Tubes

4.1.20 Valve

We used valves to allow the passage of coffee and milk from the heaters to the coffee cup through the pipes.[18]

Figure 22: Valve

4.1.21 Heater

We employed a pair of 220-volt electric water heaters to warm normal coffee and milk. These heaters are linked to an Arduino-controlled relay, which dictates their operation. The main objective of these heaters is to maintain the coffee and milk at a hot temperature consistently. They are programmed to activate automatically whenever the temperature sensor detects coffee and milk that is not hot, guaranteeing a constant supply of hot coffee.[19]

Figure 23: Heater

4.1.22 Wires

We used 3 types of wires: male-to-male, female-to-female, and male-to-female wires for various connections.

Figure 24: Wire

4.1.23 Conveyor Belt components

We used 2 rods to construct the conveyor belt. Additionally, a coupler was used to connect the rod and the stepper motor. To enable smooth movement of the cups placed on it, we integrated a friction material belt that could effortlessly rotate as the cups moved.

Figure 25: Conveyor Belt components

4.2 Software Implementation

To begin with, you can choose the order by using the LCD and keypad. Three ordering options will appear on the screen. The first option is to use an RFID card, the second option is to use a one-time password, and the last option is to use an application.
Once you have selected your preferred ordering method and confirmed your ability to place the order, a menu will appear where you can choose your desired beverage.
The next step is to choose the order from the menu which displays three options - coffee, coffee with

milk, and espresso. If coffee or coffee with milk is selected, options to select the cup size will appear. There are two options available - large or small. Once the cup size is selected, the coffee preparation process will begin. Meanwhile, the LCD screen will display wait for order and the drink's temperature until it reaches 40 degrees. The coffee preparation process will initiate by activating the stepper motors.

If you choose the espresso option, the next step is to select the concentration level. You can choose from five options: 20%, 40%, 60%, 80%, and 100%. Once you've made your selection, the screen will display "Preparing Espresso" and the preparation process will begin.

If the guest selects the alternative ordering method, they will be prompted to enter a four-digit password on a separate page. This password must satisfy a simple equation to be accepted. Specifically, the sum of the first three digits should be subtracted from the fourth digit, and the result.

must be a multiple of 2. Only passwords meeting this criterion will be accepted. Once accepted, the guest will proceed to the ordering menu and follow the same steps as before to place their order.

- **Coffee Preparation Method:**

  When preparing coffee, we first check the coffee level in the heater and its temperature. If the quantity of coffee is insufficient, we wait until the heater is filled. The temperature of the coffee should be 40 degrees Celsius, otherwise, we activate the heater. Once the coffee is heated, the cup selection process begins. First, we reset everything to the home position. Then, we activate the stepper motor to move the movable cup base until it reaches the desired cup size. Another stepper motor then pushes the cup and places it on the movable base, which continues its path until it reaches the funnel that will fill the cup. Upon the arrival of the cup, the pumps are activated to allow the coffee to flow into it. After the process is complete, the movable base returns to the home position.

- **Coffee with milk Preparation Method:**

  When preparing coffee with milk, our process ensures that the levels of both coffee and milk are checked using heaters and their respective temperatures. If there is not enough coffee or milk, we will not prepare the order until the heaters are refilled. The temperature must be 40 degrees.

  Celsius; otherwise, the heater will heat the coffee and milk further. To start, we select a cup, reset everything to the home position, and activate the stepper motor to move the movable cup base to the desired cup size. Then, another stepper motor pushes the cup and places it on the movable base. The cup continues its path until it reaches the funnel, which fills the cup. Upon arrival of the cup, the pumps are activated to allow coffee to pass into it. Once the process is complete, the movable base returns to the home position.

- **Espresso Preparation Method:**

  When an espresso is requested, the cup is selected using the same method as coffee or coffee with milk. Once it reaches the desired location, the stepper motor for selecting coffee capsules is positioned at its home position. Next, the appropriate capsule is selected based on the chosen concentration. The stepper motor responsible for pushing the capsule into place in the espresso machine is then activated. The DC motor is engaged to press the capsule in the espresso machine. Finally, the cup is filled, and the base returns to its original position.

4.3 Hardware Implementation

We have four separate units, each assigned specific responsibilities for ordering, preparing, and delivering beverages:

4.3.1 Input-Output Unit

The input and output unit comprises of an LCD screen that displays the drink menu. It also has a keypad that enables users to select and enter their orders. Additionally, users can pay for their orders using an RFID card or by entering their password. The input and output unit also has a movable base that transports the cups to the coffee filling area. Lastly, it features a base that enables users to insert capsules into the espresso machine.

4.3.2 Heating Unit

The heating unit is composed of two heaters, one for heating coffee and the other for heating milk.Each heater is equipped with sensors, an ultrasonic sensor for measuring the level of coffee or milk, and a Water Temperature Sensor for measuring the temperature of the beverage. The heaters are equipped with pumps to allow the beverage to be pumped into the cup, as well as valves to control the flow of the beverage. Finally, a relay is connected to the heater base to turn the heaters on or off.

4.3.3 Coffee Preparation Unit

The coffee preparation unit is divided into two sections. The first section is used to prepare regular coffee or coffee with milk using heaters. To fulfill the order, the cup is moved to a designated location, and then the pumps are activated, and the valves are opened. The second section is used to prepare espresso, using an espresso machine equipped with motors to press the capsule and extract the coffee.

4.3.4 Control Unit

In the control unit, all operations are controlled using Arduino.

5 Results and Discussion

At the end of this project, we succeeded in developing a smart coffee machine that operates automatically and is easy to use.
Some of the problems that we faced and how we solved them:

- Regarding the DC motor, we encountered difficulty in finding one that could exert the desired force to compress the capsule effectively. As a solution, we opted to repurpose a DC motor sourced from a car window, specifically an 8A DC motor.

- As for managing the temperature of the liquid components, we encountered issues due to temperature variations. To address this, we utilized plastic pipes capable of withstanding specific temperature levels. The main challenge here was determining the optimal temperature for the system.
- In terms of the pumps, we encountered challenges in regulating the flow of milk and coffee from the heaters to the cup when using valves. To overcome this issue, we replaced the valves with pumps to ensure a consistent and efficient flow of coffee and milk.

- Regarding the design of the machine, we faced difficulties in deciding on the appropriate design for certain components and their placement to ensure the smooth dispensing of beverages into the cup. To address this, we utilized wooden bases to elevate the heaters and the espresso machine, optimizing their positioning for improved beverage flow.

6 Future Work

- Adding drawing to coffee using milk.
- Automatic filling of coffee and milk.
- To maintain the quality of the subsequent beverage, it is essential to clean the group head.

7 Conclusions and Recommendation

7.1 Summary

Our team has developed a device capable of preparing regular coffee, coffee with milk, as well as espresso using different concentrations of capsules.

The Smart Coffee Machine stands out due to its fully automated preparation process, user-friendly interface, and ordering system. As a result, users do not need extensive knowledge of coffee or espresso preparation methods, nor do they need to know which capsules to use. All they need to do is specify the coffee concentration ratio, and the machine will take care of the selection and preparation process.

The coffee machine is designed with sensors that help to measure the amount of coffee and milk in the heaters. It also monitors the temperature of the beverage to ensure that a hot coffee drink is prepared within a few minutes.

During the development process of the smart coffee machine, we faced numerous challenges, starting from designing some components and selecting suitable motors and power sources, until we reached the final result of the smart machine.

7.2 Recommendations

- You must be cautious when using certain electronic components and sensors to avoid problems that may arise due to an increase in temperature above the required level, which could lead to the melting of pipes that are designed to withstand a specific temperature.

- Make sure that all wires are correctly connected and insulated from each other.

- When starting the project, test it in stages to ensure solving any issues that may arise easily and identifying them with ease as well.

7.3 What we have learned

- Operating with sensors such as ultrasonic and IR, along with motors like DC motors, and stepper motors, in addition to devices like pumps, and heaters

- Establishing connections and utilizing different kinds of high-voltage sensors and devices with Arduino.

References